Effects of different modifiers on the properties of wood-polymer composites

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Abstracts: Wood-polymer composites (WPC) were prepared from wood fiber and four kinds of plastics such as PE, PS, ABS, and SAN. The effects of different modifiers on the mechanical properties of the composites were studied. The results showed modifiers could raise the bonding strength of wood fiber with polymer and improve the mechanical properties of the composites. Different modifiers had different effects on the properties of wood-polymer composites, and comparatively the modifier of isocyanate produced a better result. Wood-polymer composite takes not only the advantages of both wood fiber and polymer, but waterproof, dimensional stability and dynamic strength are also significantly improved.

Key word: Wood fiber; Thermoplastic polyester; Wood-polymer composites; Modifier; Mechanical properties
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Introduction

Wood-polymer composites (WPC) are made from the wood fiber and plastics through the given technology. They have following benefits:· increasing strength and stiffness, reducing the variability in mechanical properties, which allows for higher design values, increasing service ability and fatigue performance of the product, and enhancing durability and dimensional stability of products.

Wood-polymer composites have been studied for more than 40 years by researchers. Especially these years, as development of high polymer product industry, recycling high polymer has been an important problem demanding promot solution (Yang *et al.* 2000). In addition, because of the decrease of the forest resource, the high cost and unstability of dimension of the forest products, many studies have been carried out on the wood-polymer composites increasingly (Yin *et al.* 2002) It was reported that one of the super development fields of forest products in 21st century is to increase the additional properties of wood-polymer composites fitting in with various situations (Zhang *et al.* 2001). How to improve wood-polymer composites product quality, decrease cost, improve industrial process is important for recycling plastic and exploiting poor wood.

Wood is a natural polymer material and its interface has a large quantity of functional polar groups. In the course of making wood-polymer composites, it is hard to get the adequate compatibility between the surface of hydrophily wood and adhydrophily polymer, because of the energy difference in their interface. Therefore, to improve the polarity of the wood surface and decrease the energy difference in the interface is the effective way to increase the mechanical properties of wood-polymer composites (Yan *et al.* 1999).

In this study, wood-polymer composites were prepared from wood fiber and four kinds of plastics such as PE (Polyethylene), PS (Polystyrene), ABS (Acrylonitrile- Butadiene-Styrene), SAN (Styrene-Acrylonitrile). In addition, the effects of two modifiers on the mechanical properties of composites were studied. Thus, it will provide the reference basis for the future research of the wood-polymer composites.

Materials and methods

Test apparatus and meterials

High-speed pulverizer, 50-t test performer, 100-t test heating press, rotor press, AG-10TA DJ universal testing machine, and LJ500 tensile force machine were used in test. Test materials include Wood fiber, PE, PS, ABS, SAN, dicumyl peroxide, isocyanate resin, and acetone

Test method

Process of wood fiber: Wood fiber has been shivered by mix machine and dried to 15% of water content. Then they are covered by polymer film and prepared for using.

Process of polymer: Polymer was shivered by high-speed pulverizer and screened with a sieve to receive homogeneous compound of wood fiber and polymer

Preparation of bar plate: Wood fiber was put into a rotor press, sprayed with dicumyl peroxide or matching liquor of acetone and isocyanate resin, after rotating several cycles, a polymer of 20 or 34 mesh was put into the rotor press. By adequate amalgamation, they were made to a 320 mm×340 mm loose bar plate by using of hand lay-up. At

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ambient temperature, the loose bar plate was precompacted at a compressive pressure of 1 Mpa within squeeze time of 30 s. After precompacting, it was taken out of the test performer and put into the test heating press, and compacted at a high thermal pressure of 12 MPa (4 min) and a low pressure of 4 Mpa (6 min). The thermal temperature was controlled at 175°C. High temperature mylar was used to paste bar plate surface in order to prevent melting polymer arising by "adhesion" phenomena. The final thickness of composite was controlled to 11 mm.

Testing method: Composite was divided into five long slabs (320 mm×50 mm) and given a serious number. Two of the slabs were re-divided into 8 test pieces (50 mm×50 mm), 3 pieces for test of the internal bond strength, 3 pieces for test of modulus of elasticity and modulus of rupture, and 2 pieces for test of specific absorption.

Results and discussion

Effects of different plastics and coupling agents on internal bond strength

Wood fiber mainly includes cellulose and lignin. It can be modified by the method of physics or chemistry, such as coating method, dynamic crosslinking, powder resin flexibilizer (Yang *et al.* 2001). In our study, we used different modifiers to deal with wood fiber's surface for the purpose to improve compatibility of wood fiber and polymer and adhesion ability. The internal bond strength of material was shown in Fig. 1. When the wood fiber compounded all kinds of non-polar polymer directly, the adhesion result was so bad and the polar difference was so big that the internal bond strength of composites was nearly zero. After adding modifier, their internal bond strength was significantly improved.

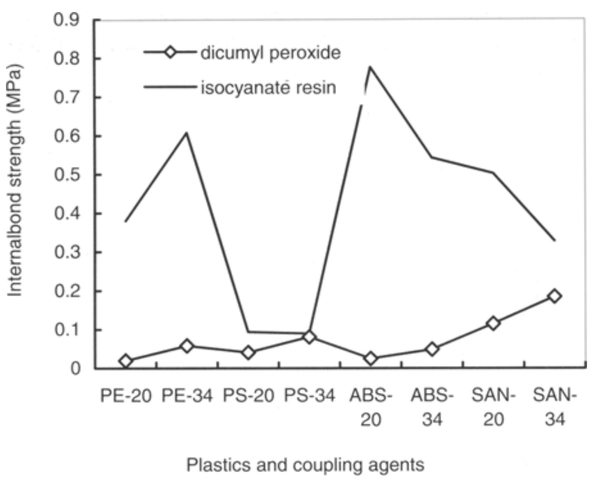

Fig. 1 Effects of different plastics and coupling agent on internal bond strength

From Fig. 1, it can be seen that the internal bond strength of the polymers with isocyanate resin was higher than those with dicumyl peroxide This indicated that socyanate resin can improve structural property of wood fiber's surface and decrease polar of its surface, at the same time, it can reduce the polarity of composites surface and the interface defect between wood fiber and plastic and improve their strength.

The effect of different plastics and coupling agent on modulus of elasticity and modulus of rupture

When dicumyl peroxide was as the coupling agent, MOR and elastic modulus of PS-34 and SAN-34 of the composites were evidently higher than those of other polymer composites (Fig. 2 and 3). When isocyanate resin was as coupling agent, the MOR and elastic modulus of ABS-20 and ABS-34 of the composites were also evidently higher than those of other polymer composites. This indicated that ABS has excellent crosslinking with wood fiber whatever the kind of coupling agent is.

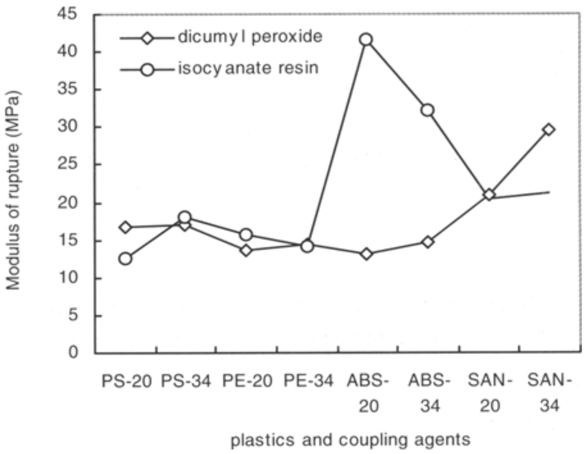

Fig. 2 The effect of different plastics and coupling agent on modulus of elasticity

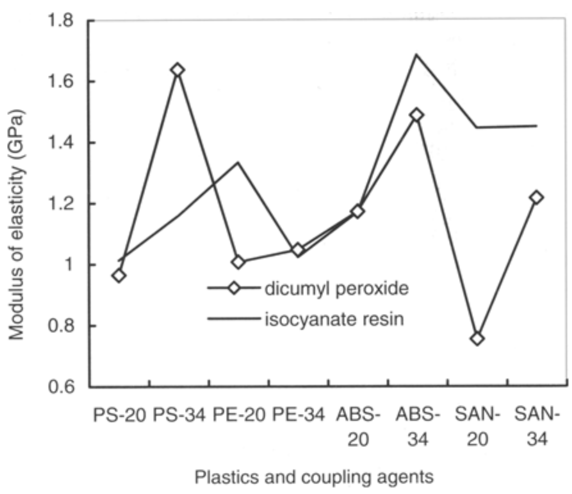

Fig. 3 The effect of different plastics and coupling agent on modulus of rupture

The effect of different plastics and coupling agent quota on thickness expansion rate of water absorbing

Thickness expansion rates of water absorbing of the 8 kinds of composites basically reached the national standard of medium-density fiberboard. Comparatively, that of composites of wood fiber and PS had an evident thickness expansion rates of water absorbing (Fig. 4) due to there still exists the free hydroxyl group in the wood fibre. Other wood-polymer composites such as PE well reacted with coupling agent, which decreased the polarity of wood fiber, thus their thickness expansion rates of water absorbing were lower.

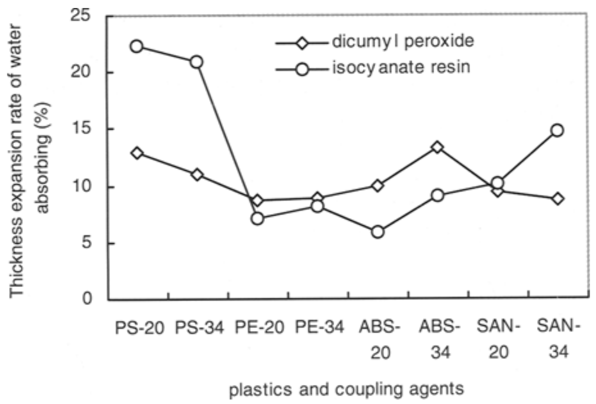

Fig. 4 The effect of different plastics and coupling agent quota on thickness expansion rate of water absorbing

Conclusions

Wood material is an asymmetric anisotropic polymer and its interface is of very complexity (Norm Kutscha 1999). In this test we used wood fiber including cellulose and lignin as the main element. There are many polar hydroxyl groups and phenolic hydroxyl in wood fiber. The surface of wood fiber has strong chemical polarity. In order to obtain the better compatibility between wood fiber and non-polar polymer, we added the coupling agent in the test. From the test, it concludes that the coupling agent added can improve the thickness expansion rate of water absorbing. This fact demonstrated that the composites have some adhydrophobic capability. When only the dicumyl peroxide was added, the MOR, elastic modulus and internal bond strength of the bar plate were not significantly improved, so that other process conditions should be considered. The isocyanate adhesive used in the test improved the mechanical properties of the composites, but some of composite strengths did not meet the demand. The adding quantities of isocyanate adhesive might be a main factor for improvement of mechanical properties of the composites.

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